

## The Energy Profit Ratio (EPR)

*Energy Profit Ratio is the ratio of energy output to input. While the EPR of oil declines, those of alternative sources are rising relatively. By Stephen Porter*

Energy Profit Ratio (EPR) is the ratio of energy output to input and indicates the feasibility of extracting energy from a given resource.

Oil, initially, is very easy to extract because it is under pressure and flows to the surface. However, as oil flows out of a reservoir, pressure in the reservoir drops and the remaining oil becomes increasingly difficult to extract. When oil is first pumped from a well, it can take the energy of one barrel of oil to get 100 barrels of oil from the ground. The EPR is  $100/1 = 100$ . Today, on average, it takes the energy of one barrel of oil to get ten barrels of oil (an EPR of 10). When it takes the energy of one barrel of oil to get one barrel of oil from the ground then the EPR is 1, and the Energy Profit is zero because there ceases to be any benefit from the activity. (When the EPR is  $1/1 = 1$ , then the Energy Profit is zero.)

According to a study done by a team from the University of Uppsala in Sweden, ultimately recoverable world oil reserves are 80% less than previously thought. This means that far fewer new reservoirs (that would have higher EPRs than used reservoirs) will be coming onstream than previously thought. The average EPR for oil will therefore not be lifted by the higher EPRs of new reservoirs.

When examining alternatives to conventional oil, it is important to think not just in terms of money, but in terms of energy in versus energy out (see table below). Canada's tar sands, for example, require 7 to 8 barrels of water plus the energy of two barrels of oil to obtain three barrels of oil (the water ends up polluted in holding ponds that may eventually be as large as Lake Ontario). The efficiency of coal as an

energy source has also declined. At one time coal had an EPR of over 50, but has since fallen to an EPR of 8 and it is expected to turn negative by 2030. Coal, natural gas and uranium have their own 'Hubbert' curves (see [The Coming Energy Crisis](#).) The other major conventional energy source, nuclear energy, is surprisingly inefficient when all the costs associated with generating it are considered. (Costs often ignored when considering nuclear power include: radiation, accidents, production of bomb material, vulnerability to terrorist attacks, no liability insurance, and storage of radioactive waste for many thousands of years.) The Energy Profit of nuclear energy is barely above zero when one considers all costs.

Energy Source	EPR
Ethanol	Less than 1
Nuclear	1 to 1.5
Oil from tar sands	1.5
Liquid Natural Gas (LNG)	2
Coal with scrubbers	2.5
Ground source heat pump	3
Thermal depolymerization	6.66
Coal	8
Conventional Oil	10
Natural gas	10
Hydroelectricity	11
Solar (photovoltaic)	15
Wind	50

Newer solar devices such as thin film panels and concentrating systems can have an EPR as high as 15. Large wind turbines can have an EPR as high as 50. Given that the EPR of wind and solar is so much higher than the EPR of oil or coal, it makes more sense to invest available resources in wind and solar rather than in exploring for more oil or digging out more coal.

The best location for generating solar energy is in deserts, both because the amount of sunshine is maximum and also because the land is not otherwise being used for agriculture. Solar

roofs are also a productive use of space, generating both electricity and hot water. Wind energy is cheaper than electricity generated by coal or nuclear energy. Due to recent price increases for natural gas, wind power is now also competitive with electricity generated by natural gas.

The main task at hand is to develop a primary source of energy. Compressed air, batteries, and hydrogen are energy carriers or storage devices, they are not primary sources of energy. Wind power, solar power, and geothermal energy are primary sources of energy. These are the alternatives we should be developing seriously as a replacement for oil.

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## SIDEBARS

### The EPR of Primary Energy Sources

The EPR of oil from conventional sources is 10, of natural gas 10, of hydroelectricity 11, and nuclear power just above 1. The two most promising sources of primary energy are wind (EPR of 50) and solar energy (EPR of 15).

See the accompanying [EPR table](#) for a listing of other PE sources.